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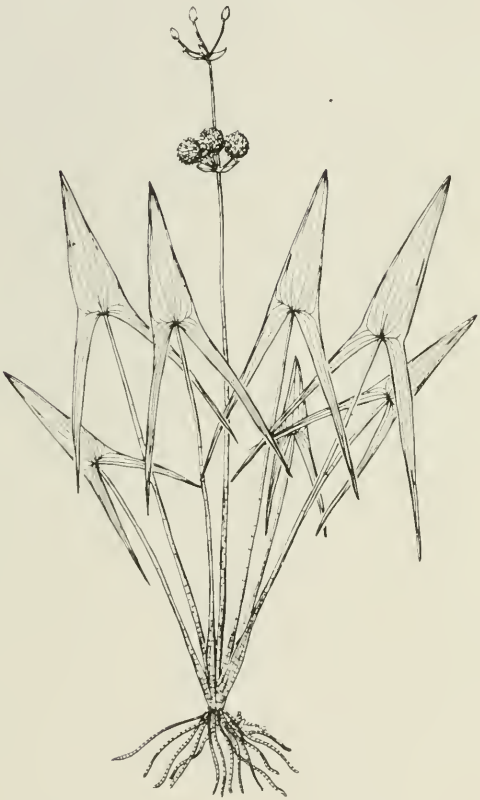

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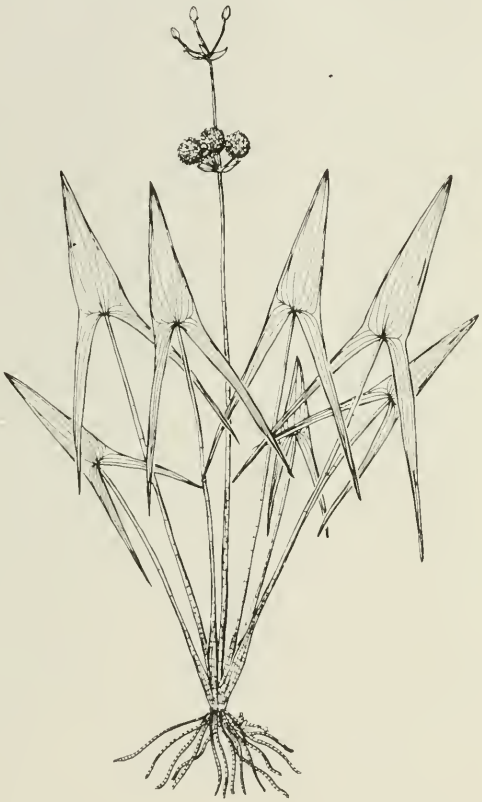

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We wish to thank Drs. Robert K. Godfrey, Robert R. Haynes, and Arthur C. Mathieson for their helpful comments on the manuscript. Bruce Sorrie kindly supplied locality data not documented in herbaria for some of the rarer taxa occurring in southeastern Massachusetts. We are also grateful to the curators of the following herbaria for use of their collections: BOSC, BRU, CONN, CUW, GH, HNH, KIRI, MASS, MAINE, NCBS, NHA, NEBC, VT, and YU. A special thanks is extended to Pamela Bruns, who prepared the illustrations.

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ABSTRACT

This paper is the third in a series of reports on the aquatic and wetland flora of New England. It treats all species of the Alismataceae occurring in New England and includes keys, comments on taxonomy and nomenclature, habitat and distributional information, water chemistry data, illustrations, and dot maps. Those species regarded as rare and endangered in the New England Region or in one or more of the six New England states are also noted. One species, *Echinodorus parvulus,* is believed extinct in our region.

KEY WORDS: Aquatic plants, New England Flora, Taxonomy, Alismataceae, *Alisma, Echinodorus, Sagittaria,* Water-plantain, Burhead, Arrowhead, Wapato, Duck-potato.

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Aquatic Vascular Plants of New England: Part 3. Alismataceae

by

C. B. Hellquist[1] and G. E. Crow[2]

INTRODUCTION

This is the third in a series of reports on the aquatic and wetland flora of New England. These reports are intended to aid conservationists, fish and game personnel, consultants, botanists, and students in the identification of aquatic plants. The coverage is strictly New England but is of value throughout the northeast. Data have been gathered from herbaria in New England and from personal field work.

Chemical data presented represent samples from many waters throughout New England. The alkalinity readings are total alkalinity, expressed as milligrams per liter (mg/l) $CaCO_3$. Since pH and alkalinity vary greatly during the day, the values are only indicative of the water quality. Chloride values are given where data are available and of value.

The rare and endangered plant lists referred to are those prepared for each of the six New England states by the New England Botanical Club in cooperation with the United States Fish and Wildlife Service, Office of Endangered Species, Newton Corner, MA (RI — Church and Champlin, 1978; MA — Coddington and Field, 1978; VT — Countryman, 1978; ME — Eastman, 1978; CT — Mehrhoff, 1978; NH — Storks and Crow, 1978). Taxa indicated as rare, threatened or endangered for the entire New England Region are also noted (Crow *et al.*, 1981).

We invite comments and/or criticisms on this treatment. Information on any species omitted or any known localities not documented by us will be welcomed. If anyone is interested in specific localities of any of the species indicated on the dot maps, please contact us.

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ALISMATACEAE

1. Pistils in a single ring on a flat receptacle (figs. 1, 2); flowers all perfect, stamens 6.
   ..... 1. *Alisma*
1. Pistils in a dense globose head (figs. 4E, 10D); flowers perfect or imperfect, stamens more than 6.
   2. Flowers perfect; achenes plump, conspicuously ridged, not winged (fig. 3C); leaf blade never sagittate; roots not septate.
      ..... 2. *Echinodorus*
   2. Flowers imperfect, uppermost flowers mostly staminate (fig. 10A) or plants dioecious; achenes flattened, winged, not ridged (figs. 10E, 12C, 14D); leaf blade often sagittate; roots septate (fig. 4A, 6A, 9A).
      ..... 3. *Sagittaria*

Alisma (Water-plantain)

Plants of shores and marshes, often submersed in water up to one meter in depth; growing from corm-like rootstalks; leaves all basal, ribbon-like, ovate or elliptical; flowers perfect, borne in a panicle; fruit an achene, borne in a circle on a flattened receptacle.

Key to Species

1. Leaves submersed and ribbon-like (fig. 1B) or if emersed, lanceolate to narrowly elliptic, 0.5-2.0 cm broad (fig. 1A); achenes with two dorsal grooves and a central ridge (fig. 1E).
   ..... 1. *A. gramineum*
1. Leaves emersed with ovate to elliptic blades (fig. 2A); occasionally submersed or floating (fig. 2B), up to 15 cm broad; achenes with single dorsal groove (fig. 2F).
   2. Flowers 7.0-13.0 mm broad; sepals at anthesis 3.0-4.0 mm long; petals 3.5-6.0 mm long; fruiting heads 4.0-7.0 mm in diameter; achenes 2.2-3.0 mm long.
      ..... 2a. *A. plantago-aquatica* var. *americanum*
   2. Flowers 3.0-3.5 mm broad; sepals at anthesis 2.0-2.5 mm long; petals 1.0-2.0 mm long; fruiting heads 3.0-4.0 mm broad; achenes 1.5-2.0 mm long.
      ..... 2b. *A. plantago-aquatica* var. *parviflorum*

1. *Alisma gramineum* Lej. Fig. 1, Map 1

Locally abundant in calcareous waters and shores of Lake Champlain and its tributaries. Plants are often found submersed in water to a depth of about one meter. This variable species is sometimes divided into two or three dubious varieties based primarily on vegetative features which appear to be environmentally induced. First discovered in New England in 1961 at Shelburne Bay on Lake Champlain (Countryman, 1968), this species appears to be spreading rapidly throughout the lake region. Range extends from Vermont and southwest Quebec west to Wisconsin, Alberta, and British Columbia, south to South Dakota, Colorado, Nevada, and northern California.

alkalinity: 47.5 mg/l
pH: 7.5

2. *Alisma plantago-aquatica* L.

2a. *A. plantago-aquatica* var. *americanum* Schultes and Schultes Fig. 2, Map 2

Scattered throughout New England along shores, in marshes, ponds, streams, ditches, and in shallow water. This northern taxon is treated by some authors as *Alisma triviale* Pursh. Range extends from Quebec west to British Columbia, south to Maryland and west Virginia, Michigan, Iowa, Nebraska, New Mexico, Arizona, California, and northern Mexico.

alkalinity: mean 30.5 mg/l; range 13.5-47.5 mg/l
pH: mean 7.0; range 6.5-7.5

2b. *A. plantago-aquatica* var. *parviflorum* (Pursh) Torrey Fig. 2, Map 3

Abundant along shores, in marshes, ponds, streams, ditches and in shallow water throughout New England. This more southern taxon is treated by some authors as *Alisma subcordatum* Raf. Most plants of var. *americanum* and var. *parviflorum* are distinct at the extremes of their geographical ranges but in New England intermediate plants occur, sometimes making identification difficult. Range extends from Maine west to New York, Ontario, Minnesota, and Nebraska, south to Florida, and Texas.

alkalinity: mean 69.5 mg/l; range 11.0-290.0 mg/l
pH: mean 7.3; range 6.5-8.4

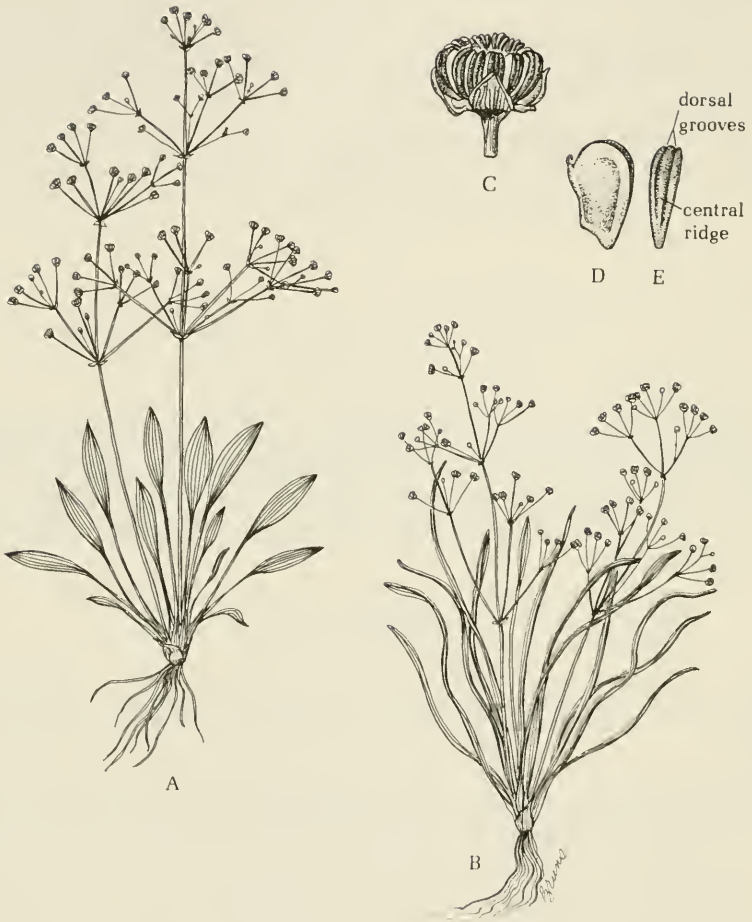
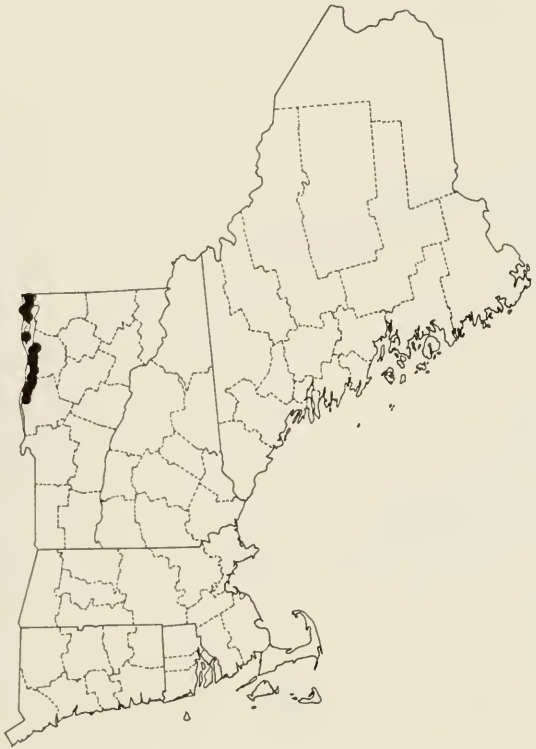
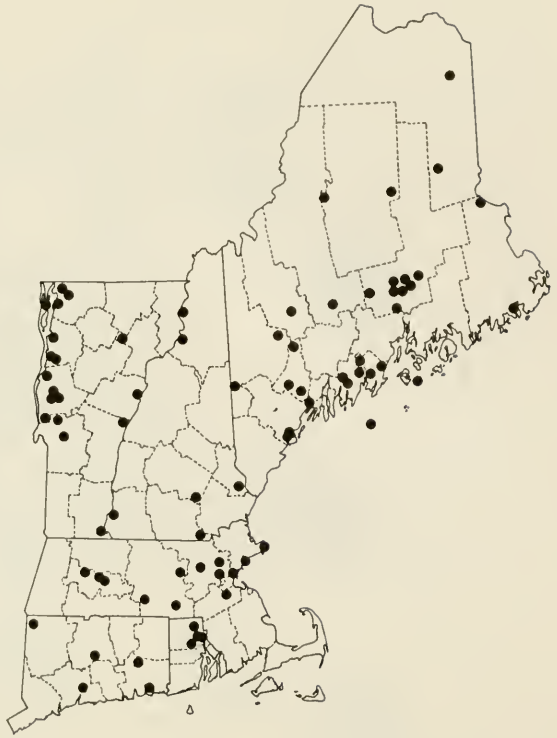


Figure 1.
Alisma gramineum: **A. habit of emersed plant, x ¼. B. habit of submersed plant, x ¼. C. fruiting head, x 4. D. achene, side view, x 8. E. achene, end view, x 8.**

Figure 2.
***Alisma plantago-aquatica* var. *parviflorum*: A. habit of emersed plant, x ¼. B. habit of submersed plant, x ½. C. flower, x 2. D. fruiting head, x 4. E. achene, side view, x 8. F. achene, end view, x 8.**
var. *americanum*: G. flower, x 2.



Map 1.
Alisma gramineum



Map 2.
Alisma plantago-aquatica
var. *americanum*

Echinodorus (Burhead)

Plants of sandy shores, often spreading by creeping shoots; leaves basal, submersed leaves lance-linear phyllodia; emersed leaves petiolate with a lanceolate blade; flowers perfect in an umbel; fruit an achene.

1. *Echinodorus parvulus* Engelmann Fig. 3, Map 4

A plant of sandy shores which has been reported from four sites in eastern Massachusetts, but now believed extinct in our region. The last known locality was Winter Pond, Winchester, Massachusetts. The pond has been treated with herbicides on several occasions and the species has not been reported there since 1970.

The taxon is treated by some authors as *Echinodorus tenellus* (Mart.) Buchenau var. *parvulus* (Engelmann) Fassett. Populations apparently occur locally. Range extends from Massachusetts west to Ontario and Minnesota, south to central Florida and southern Texas.

Rare and endangered plant lists: Massachusetts, New England

Sagittaria (Arrowhead, Wapato, Duck-potato)

Plants of fresh or saline waters; growing in marshes, ditches, pond shores, lakes, streams, and estuaries; emergent or submersed; growing from fibrous septate roots; spreading by stolons, some of which produce tubers. Leaves extremely variable, blades sagittate or hastate to lanceolate, or bladeless, phyllodial, ribbon-like to subulate, submersed, floating or erect; flowers white, whorled in three's; bracts membranous; uppermost flowers usually staminate; fruit an achene.

Key to Species

1. Sepals of mature flowers appressed (fig. 4D); pedicels thick and spongy (fig. 4A); leaves erect, spongy (fig. 4A); tidal mudflats.
   ..... 1. *S. montevidensis* ssp. *spongiosus*
1. Sepals of mature flowers reflexed (fig. 5B); pedicels more slender, not spongy; leaves erect or lax, not spongy; mostly freshwater.
   2. Leaves narrow linear phyllodia, 1-3 mm wide (fig. 5A, 6A), occasionally with floating ends broadening into a narrow blade (fig. 6A).
      3. Plants small with linear leaves up to 30 cm long (fig. 5A); mostly estuarine.
   ..... 2a. *S. subulata* var. *subulata*

3. Plants with long linear leaves over 30 cm (fig. 6A); in fast moving freshwater.
. . . . . 2b. *S. subulata* var. *gracillima*

2. Leaves differentiated into petiole and blade (fig. 8A) or if bladeless, then leaves terete and quill-like (fig. 7A, B), occasionally submersed leaves in populations ribbon-like (fig. 13A), usually greater than 3 mm wide.
4. Stamens with pubescent filaments (fig. 7E); leaves not sagittate (rarely in *S. rigida*).
5. Emersed and submersed leaves terete and quill-like (fig. 7A, B).
. . . . . 3. *S. teres*
5. Emersed and submersed leaves flattened (figs. 8, 9, 11, 13).
6. Flower and fruit heads pedicelled (fig. 8A); scape straight, upright (fig. 8B); leaves linear-lanceolate phyllodia (fig. 8B, C) or with narrow to broad lanceolate tapering blades; achenes rarely forming (in New England), 1.5-2.0 mm long, with small beak, 0.1-0.3 mm long.
. . . . . 4. *S. graminea*
6. Flower and fruit heads sessile or nearly so (fig. 9A); scape weak, often bent (fig. 9A); leaves erect, lanceolate (fig. 9C) to ovate (fig. 9B), occasionally with basal lobes (fig. 9D); achenes regularly formed, 2.5-4.0 mm long, with erect or arching beak 1.0-1.5 mm long (fig. 9F).
. . . . . 5. *S. rigida*

4. Stamens with glabrous filaments; leaves mostly sagittate (fig. 10A).
7. Achenes with beak horizontal (fig. 10E).
. . . . . 6. *S. latifolia*
7. Achenes with beak erect (fig. 12C, 14D).
8. Achenes 2.0-2.6 mm long, with tiny erect beak, 0.2-0.4 mm long (fig. 12C); submersed plants forming broad, ribbon-like leaves (fig. 13A) and/or floating lanceolate or sagittate leaves (fig. 13A, B); emersed plants usually with recurved petioles (fig. 12A).
. . . . . 7. *S. cuneata*
8. Achenes 3.6-4.5 mm long with erect or oblique beak 1.5-2.0 mm long (fig. 14D); plants always emersed, petioles ascending (fig. 14A, B).
. . . . . 8. *S. engelmanniana*

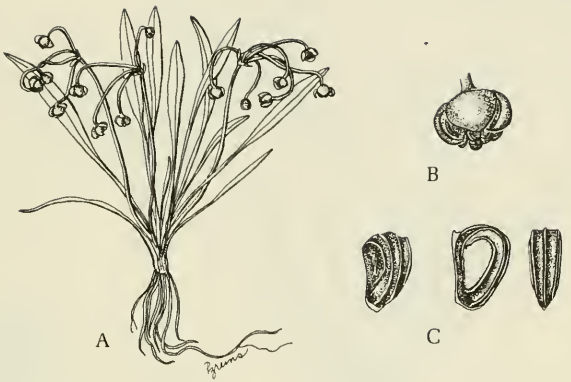


Figure 3.
Echinodorus parvulus: **A. habit, x 1. B. nodding flower, x 3½. C. achene, oblique, side, and end views, x 10.**

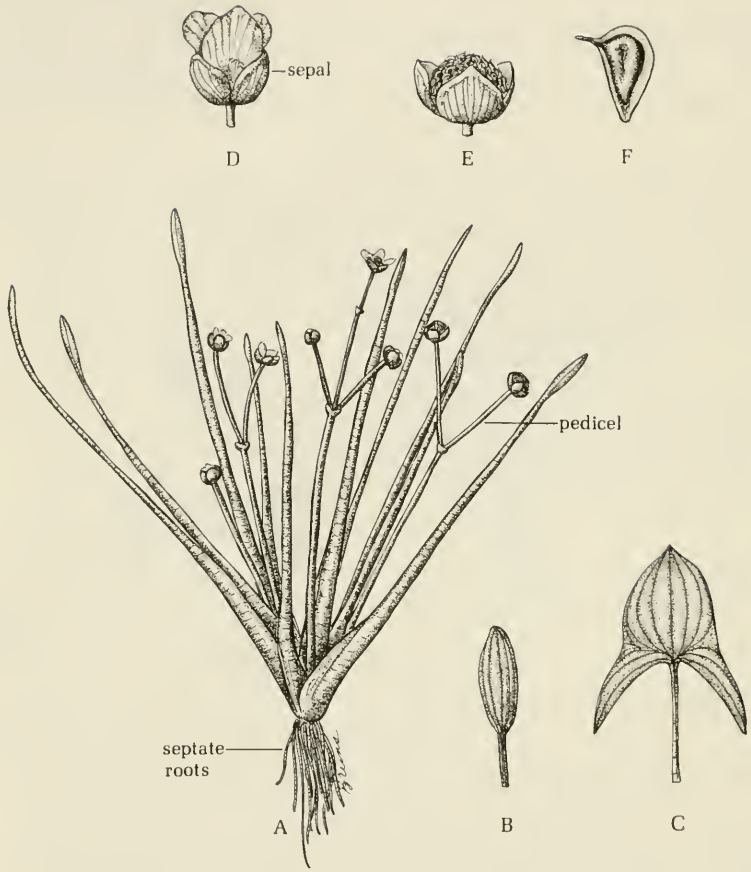
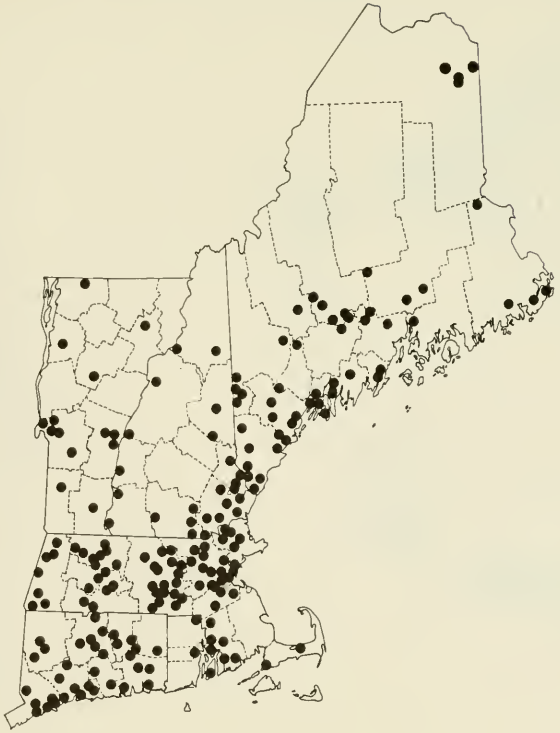
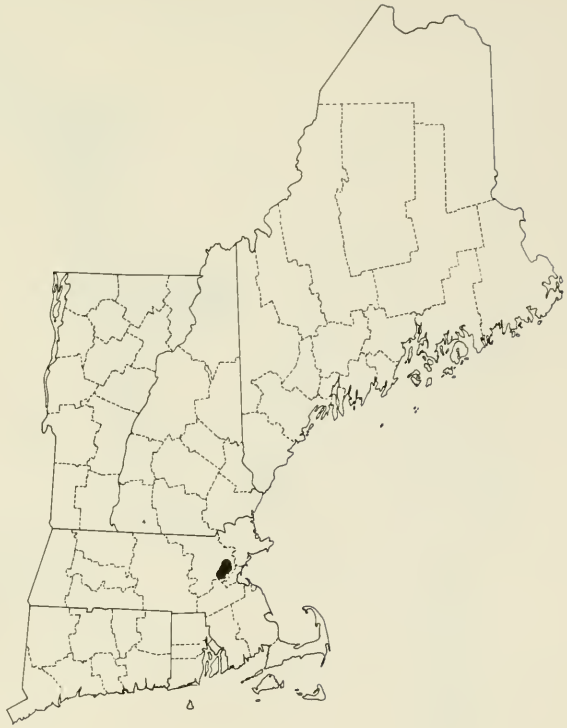


Figure 4.
***Sagittaria montevidensis* ssp. *spongiosus:* A. habit, x ½. B., C. leaf blades, x ½. D. flower, x 2. E. fruiting head, x 2. F. achene, x 6.**



Map 3.
Alisma plantago-aquatica
var. *parviflorum*



Map 4.
Echinodorus parvulus

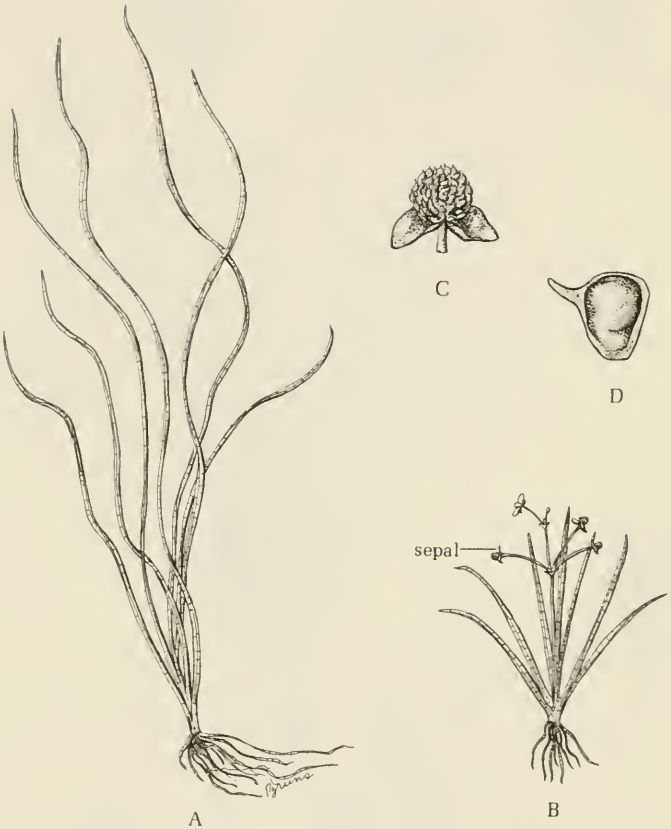


Figure 5.
Sagittaria subulata* var. *subulata: **A. habit of submersed plant, x ½. B. habit of emersed plant, x ½. C. fruiting head, x 3. D. achene, x 15.**

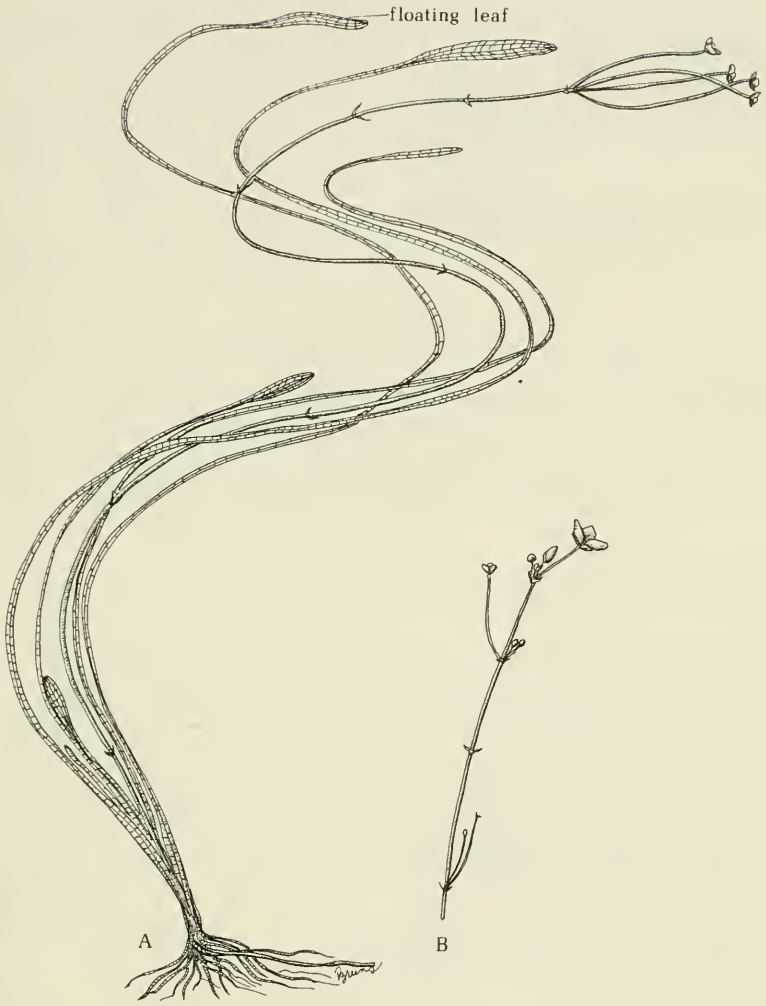
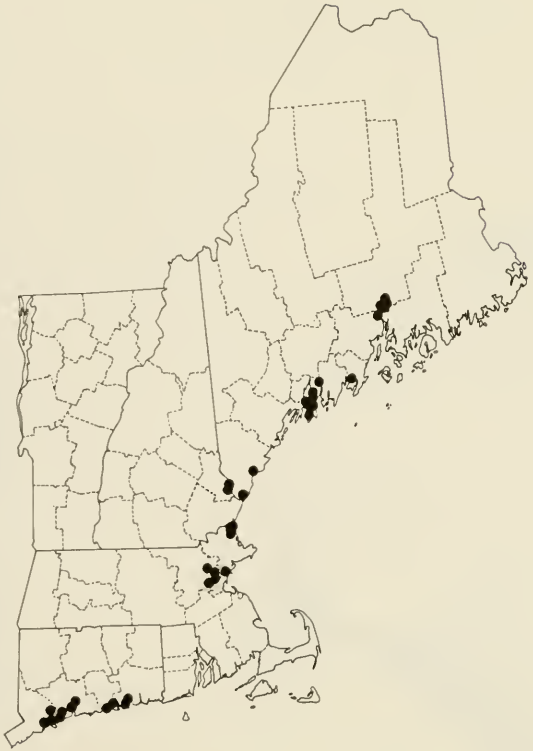
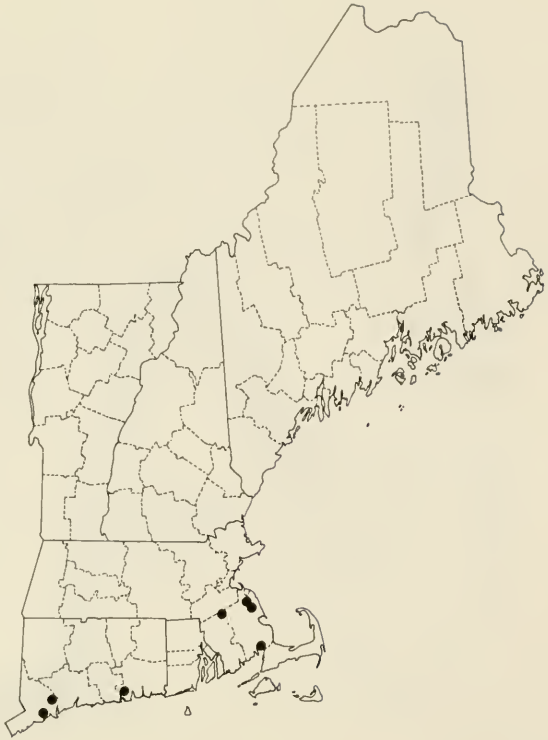


Figure 6.
Sagittaria subulata* var. *gracillima: **A. habit, x ½. B. inflorescence, x ½.**



Map 5.
Sagittaria montevidensis
ssp. *spongiosus*



Map 6.
Sagittaria subulata
var. *subulata*

1. *Sagittaria montevidensis* Cham. and Schlect. ssp. *spongiosus* (Engelm.) Bogin Fig. 4, Map 5

Rare on mud flats in estuarine sites. Although the leaves are typically thick spongy phyllodia, occasionally an elliptical to narrowly-sagittate leaf may be encountered. The type station for this taxon is the Merrimack River, Newburyport, Massachusetts. Long known as *Lophotocarpus spongiosus* (Engelm.) J. G. Smith, Bogin (1953) treats it in the genus *Sagittaria*. Range extends from New Brunswick south to Virginia.

Rare and endangered plant lists: New Hampshire, Massachusetts, Connecticut, New England

2. *Sagittaria subulata* (L.) Buchenau

2a. *Sagittaria subulata* var. *subulata* Fig 5, Map 6

Rare in tidal waters of Massachusetts and Connecticut; reported from one freshwater site in Massachusetts. This plant forms small rosettes of subulate leaves or plants with elongate leaves up to 30 cm. Range extends from Massachusetts southward along the Atlantic Coast and Gulf States to Mississippi.

2b. *Sagittaria subulata* var. *gracillima* (S. Wats.) J. G. Smith Fig. 6, Map 7

Uncommon in rivers of Massachusetts, Rhode Island, and Connecticut. The variety occasionally flowers, but has never been observed fruiting in New England. The type locality is the Neponset River, Readville, Massachusetts. Adams and Godfrey (1961) regard this phase of the *S. subulata* complex as having strongest affinities with *S. stagnorum* Small; Godfrey and Wooten (1979) include it within *S. stagnorum* in their flora. Range extends from Massachusetts south to eastern Pennsylvania, Florida, and Alabama, with one location in North Carolina.

alkalinity: mean 20.3 mg/l; range 15.0-35.0 mg/l
pH: mean 6.7; range 6.7-6.8

3. *Sagittaria teres* S. Wats. Fig. 7, Map 8

Common in sandy acid coastal plain freshwater ponds of southeastern Massachusetts, rare inland in Massachusetts and Rhode Island. The type locality is Lewis Pond, Hyannis, Massachusetts. Bogin (1955) includes this as a variety of *Sagittaria graminea*. However, based in part on the observation that this taxon of limited habitat fruits abundantly in New England, while *S. graminea* does not, we agree with Beal (1960) in maintaining it as a distinct species. Presently there are 61 locations known for this species in Massachusetts. Range

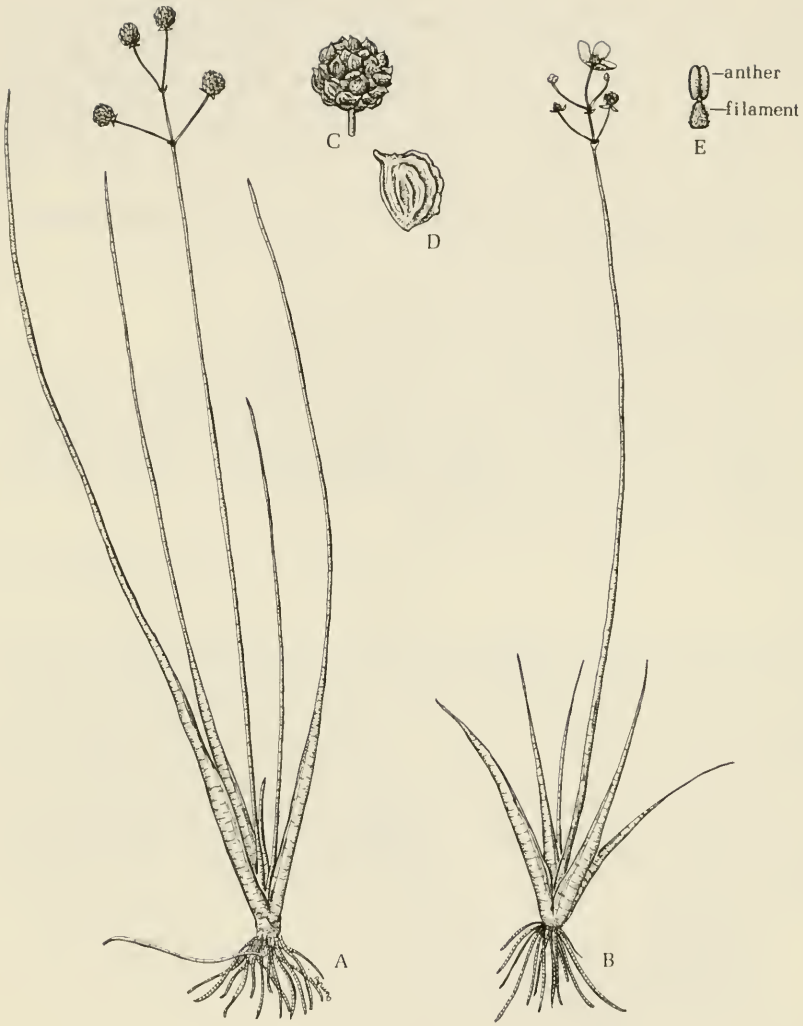


Figure 7.
Sagittaria teres: **A. habit of partially submersed plant, x ½. B. habit of emersed plant, x ½. C. fruiting head, x 1½. D. achene, x 5. E. stamen showing pubescent filament, x 5.**

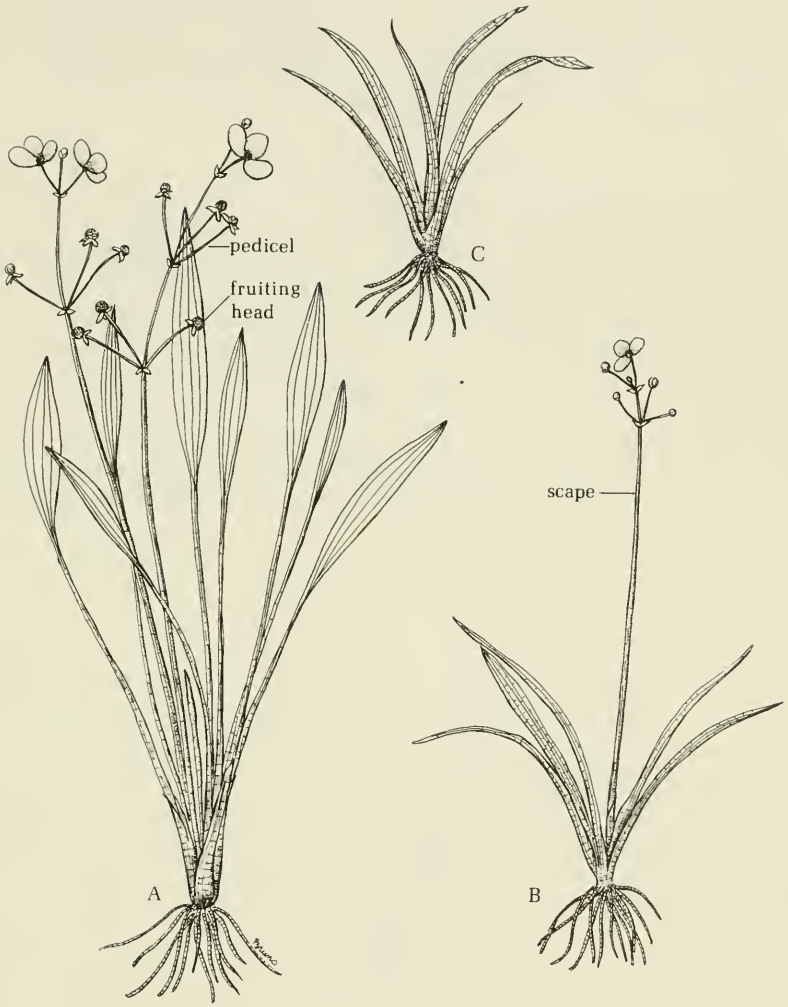
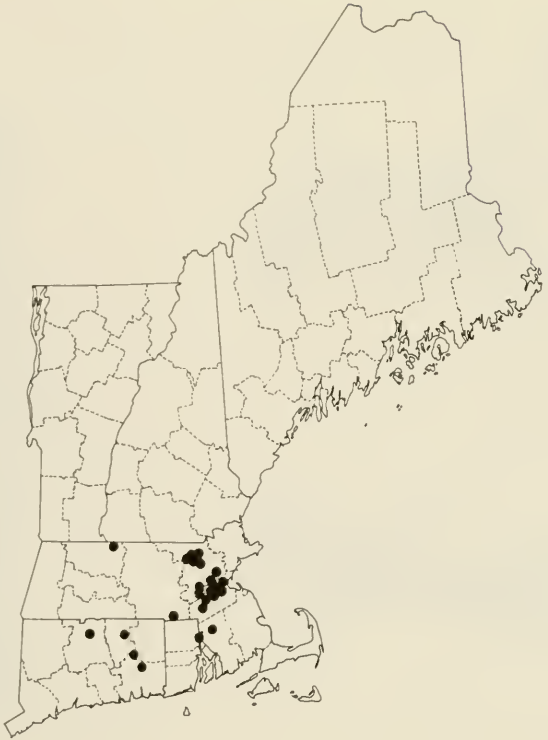
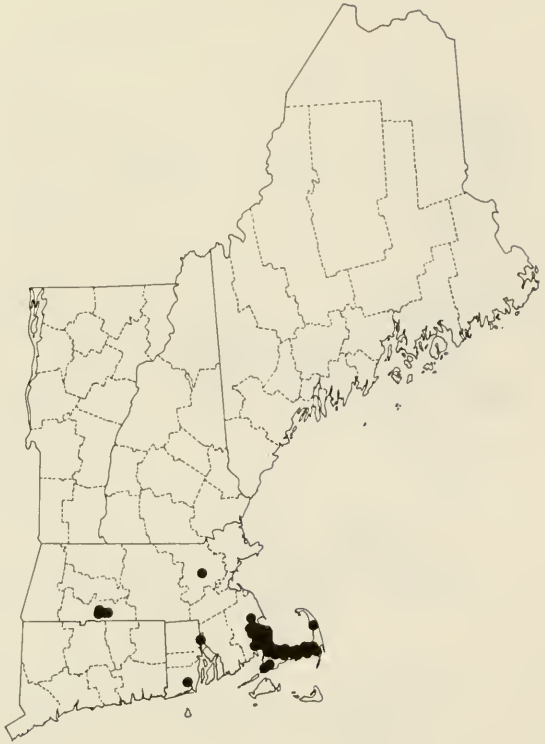


Figure 8.
Sagittaria graminea: **A. habit of plant with lanceolate tapering blades, x ½. B. habit of plant with linear phyllodia, x ½. C. submersed sterile rosette, x ½.**



Map 7.
Sagittaria subulata
var. ***gracillima***



Map 8.
Sagittaria teres

extends from Massachusetts and Rhode Island south to southern New Jersey. Carolina plants called *S. teres* by Beal (1960) are identified by Godfrey and Adams (1964) as *S. isoetiformis.*

Rare and endangered plant lists: Massachusetts, New England

alkalinity: mean 5.5 mg/l; range 4.0-7.0 mg/l
pH: mean 5.2; range 4.5-5.9

4. *Sagittaria graminea* Michx. Fig. 8, Map 9

Common in freshwater ponds and lakes throughout New England; uncommon in tidal waters. The taxon is more abundant in the acid waters of eastern New England. *Sagittaria graminea* has a number of recognized varieties in the United States, but only the typical variety is found in New England. This treatment includes *S. eatonii* J. G. Smith of tidal areas. A single record of this species fruiting in New England is known. This species of *Sagittaria* produces the greatest number of sterile rosettes in our area. Range extends from Newfoundland and southern Labrador west to Ontario and Minnesota, south to Florida, Illinois, Missouri, and Texas; Cuba.

alkalinity: mean 18.7 mg/l; range 3.0-111.5 mg/l
pH: mean 7.0; range 6.4-8.4

5. *Sagittaria rigida* Pursh Fig. 9, Map 10

Common in the Champlain Valley of Vermont, widely scattered and uncommon elsewhere in New England. The plant has a tendency to be found in more alkaline waters; occasionally found in tidal waters. The leaf blades are quite variable, ranging from slender lanceolate leaf to broad oval leaf, and occasionally becoming somewhat sagittate with the development of small basal lobes. A submerged form with bladeless slender phyllodia is sometimes found. Range extends from Quebec and Maine west to Ontario and Minnesota, south to Virginia, Kentucky, Tennessee, Missouri, and Nebraska.

alkalinity: mean 31.3 mg/l; range 10.0-57.5 mg/l
pH: mean 7.4; range 6.5-8.9

6. *Sagittaria latifolia* Willd. Fig. 10, 11, Map 11

Extremely common throughout New England in acid and alkaline waters. The erect leaves are extremely variable, ranging from narrow leaves without a blade to narrowly sagittate to broadly sagittate leaves. Several dubious varieties and forms have been named based on leaf shapes, but leaves delineating these names may all occur on the same plant. It is the most common *Sagittaria* in New England and the northeast. Range extends from New Brunswick west to British

Columbia, south to Florida, Alabama, Louisiana, and California; Mexico and South America.

alkalinity: mean 26.4 mg/l; range 1.5-290.0 mg/l
pH: mean 6.9; range 5.0-9.2

7. *Sagittaria cuneata* Sheldon Fig. 12, 13, Map 12

Common in northern New England, rare throughout the rest of the region. This is another variable species. In deep water it may produce sterile rosettes like those of *S. graminea.* Rosettes may also produce floating leaves with a lanceolate or sagittate blade. In rivers extremely broad, flat, linear leaves, similar to those of *Vallisneria americana* but lacking the central lacunae band, are formed. When emersed the plant forms sagittate or ovate leaves that tend to droop rather than stand erect. Range extends from Gaspe County, Quebec west to British Columbia, south to New England, New York, Ohio, Illinois, Iowa, Kansas, Texas, New Mexico, Arizona, and California.

Rare and endangered plant lists: New Hampshire, Massachusetts, Connectict

alkalinity: mean 36.7 mg/l; range 5.0-127.0 mg/l
pH: mean 7.4; range 6.8-8.9

8. *Sagittaria engelmanniana* J. G. Smith Fig. 14, Map 13

Common in acid waters of marshes, bogs and sandy ponds of southeastern New England. The type locality is a sphagnum bog in Uxbridge, Massachusetts. The species exhibits much variability in the width of the sagittate leaves and sterile plants look similar to *Sagittaria latifolia.* The upright beak of the achene is the best diagnostic characteristic for identification. Range extends from eastern Massachusetts south to Florida.

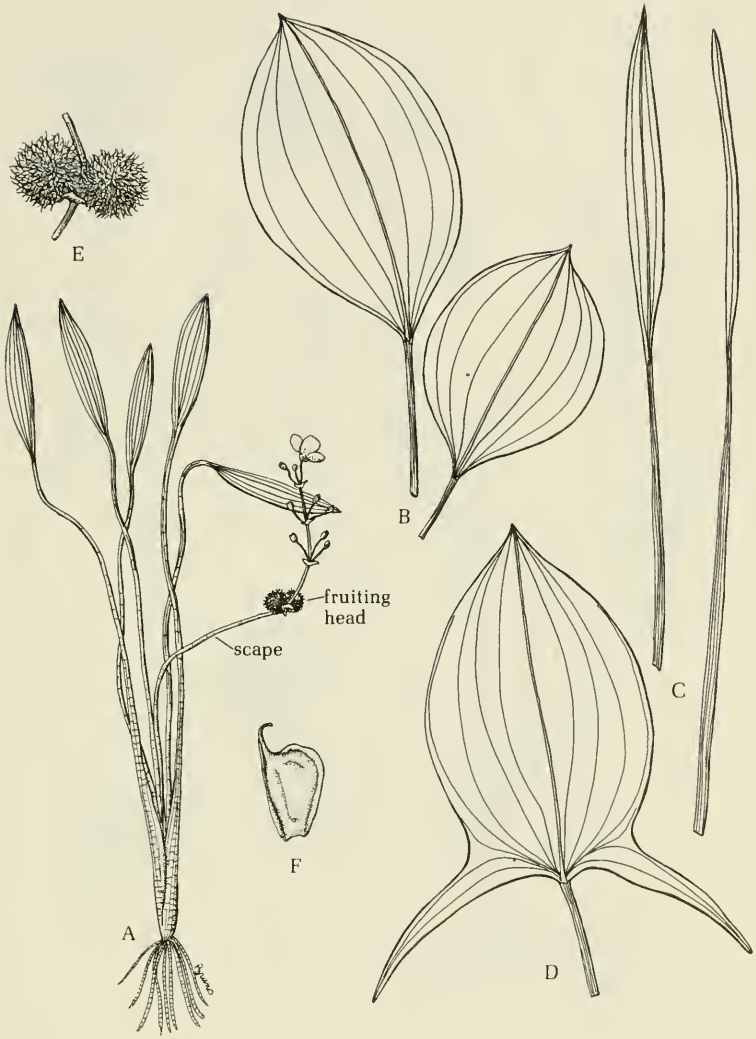


Figure 9.
Sagittaria rigida: **A. habit, x ¼. B., C., D. leaf blade variations, x ½. E. paired fruiting heads, x 1. F. achene, x 5.**

Figure 10.
Sagittaria latifolia: **A. habit, x ½. B. pistillate flower, x 1. C. staminate flower, x 1. D. fruiting head, x 1. E. achene, x 5.**

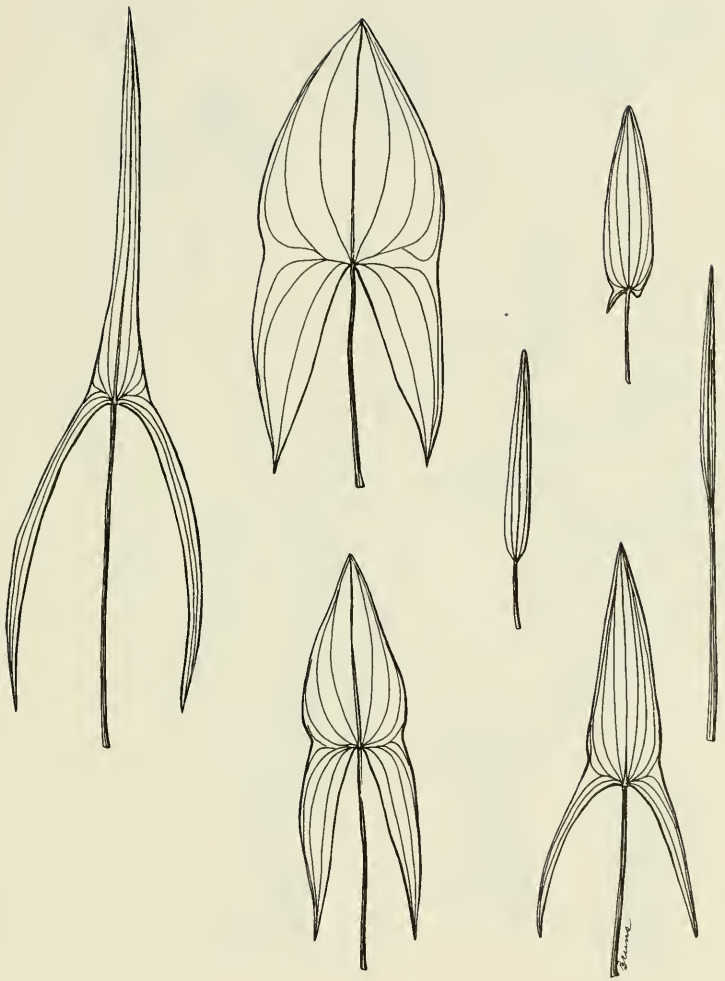


Figure 11.
Sagittaria latifolia: **leaf variations, all x ½.**

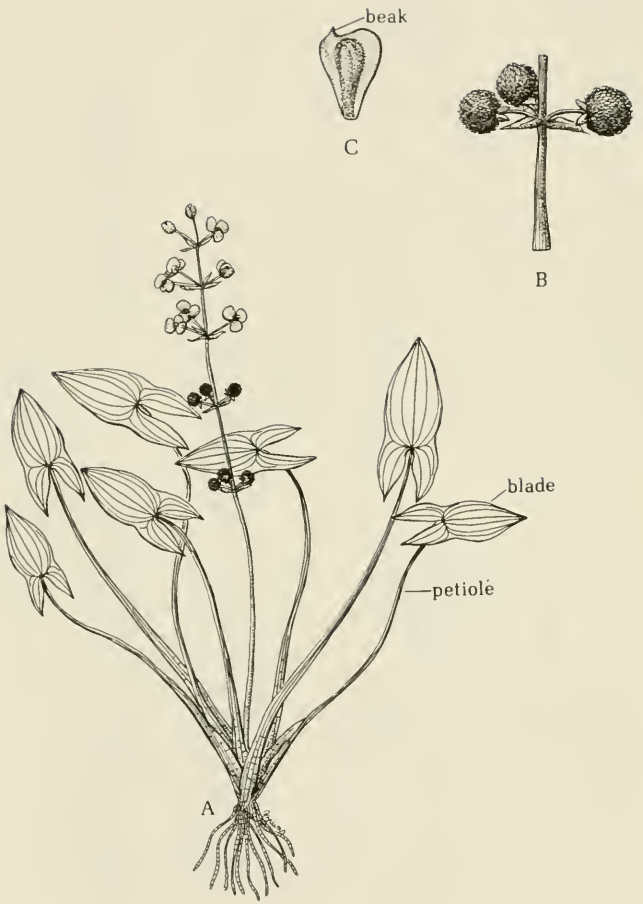


Figure 12.
Sagittaria cuneata: **A. habit of emergent plant, x ¼. B. fruiting heads, x 1. C. achene, x 5.**

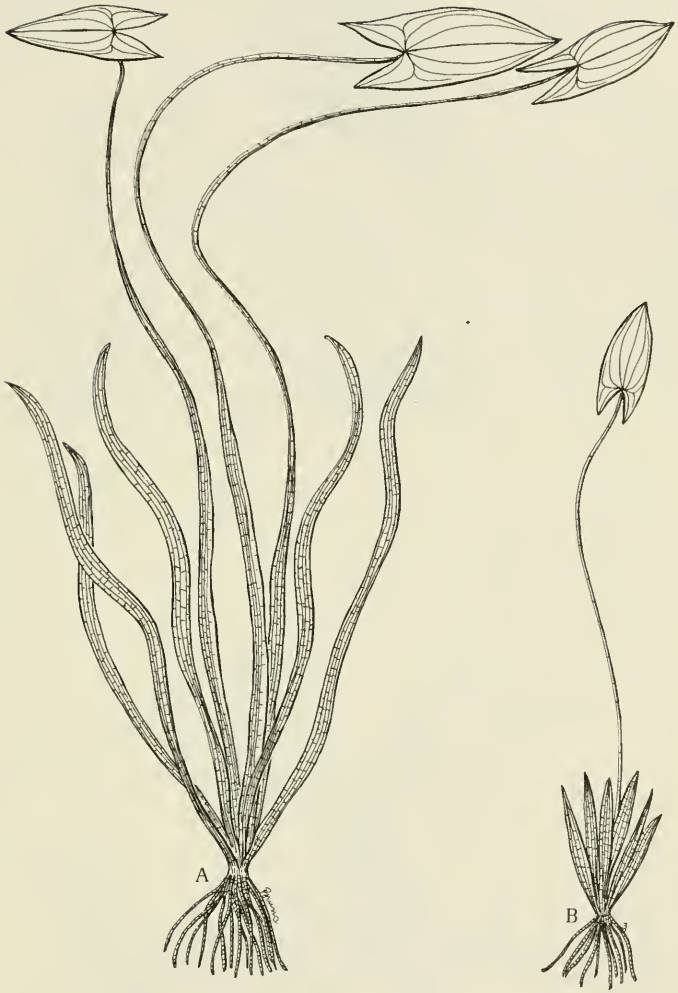
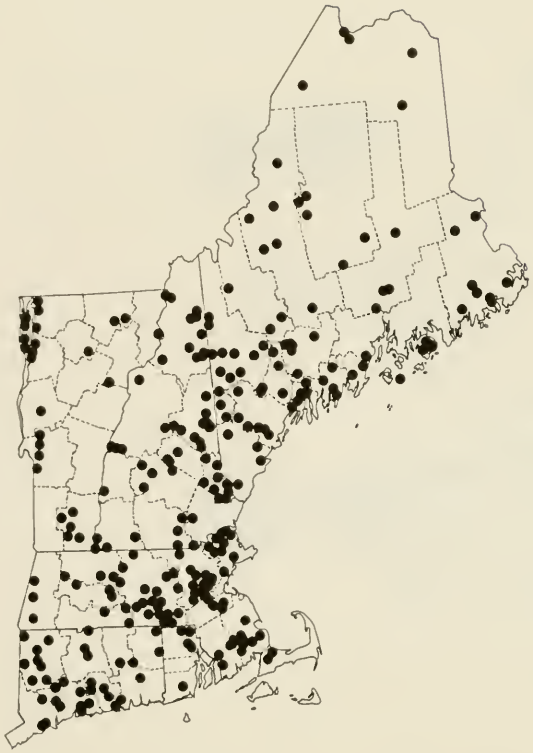
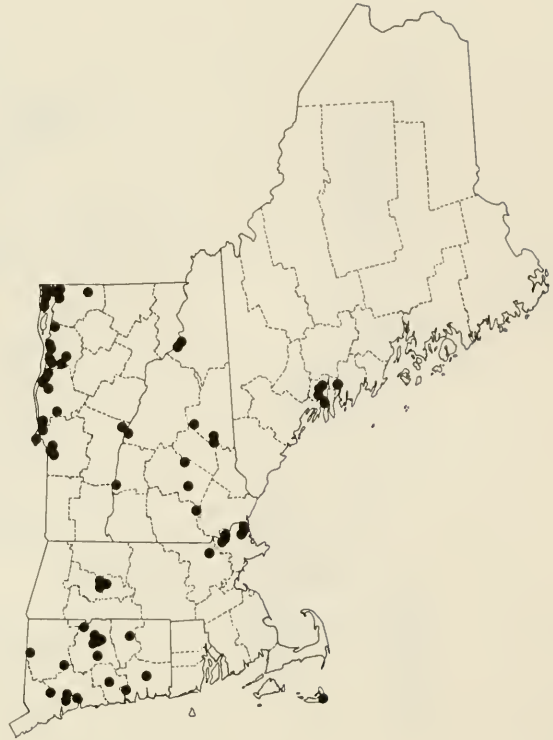


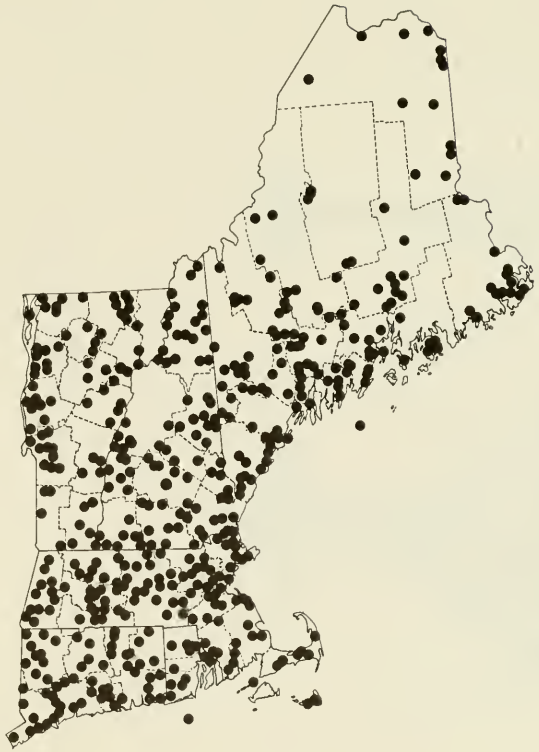
Figure 13.
Sagittaria cuneata: **A. habit of submersed plant with flat, linear leaves and sagittate floating leaves, x ¼. B. sterile rosette, x ¼.**



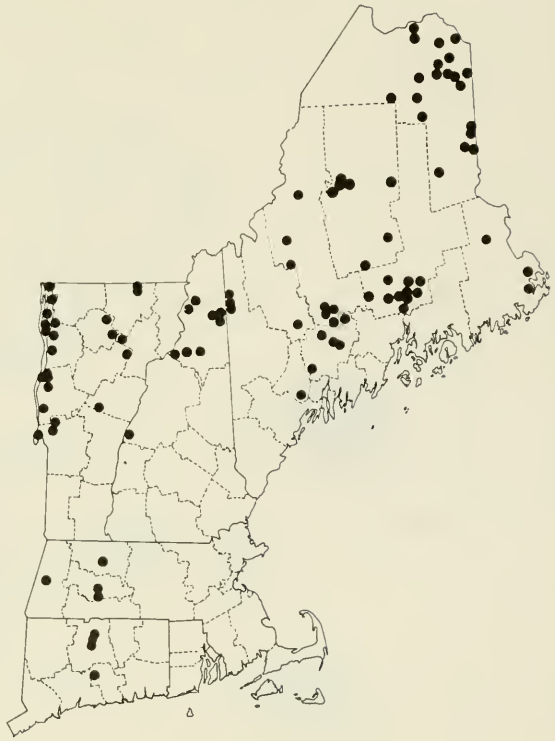
Map 9.
Sagittaria graminea



Map 10.
Sagittaria rigida

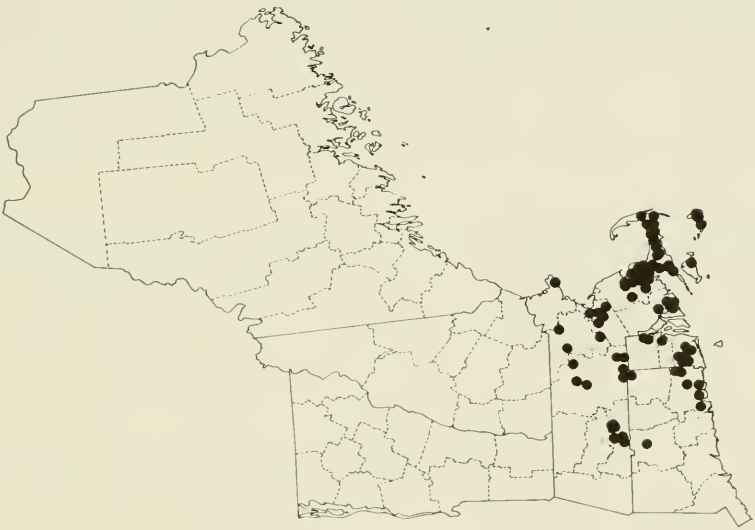


Map 11.
Sagittaria latifolia



Map 12.
Sagittaria cuneata

Figure 14.
Sagittaria engelmanniana: **A. habit, x ¼. B. habit, x ¼. C. fruiting head, x 1. D. achene, x 4.**



Map 13.
Sagittaria engelmanniana

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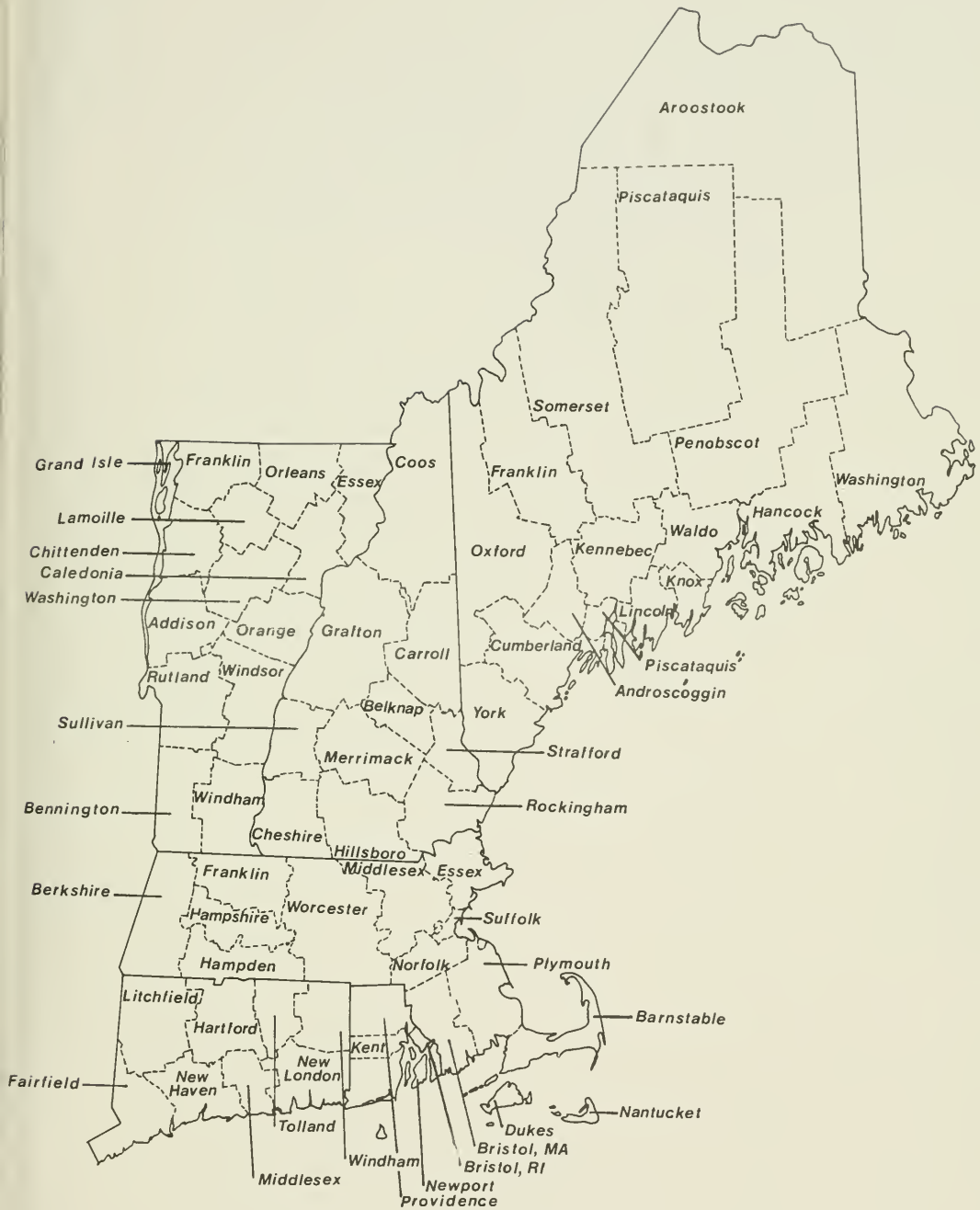
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Oxford
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Androscoggin
York
Carroll
Belknap
Strafford
Rockingham
Merrimack
Hillsboro
Middlesex
Essex
Suffolk
Norfolk
Plymouth
Barnstable
Nantucket
Dukes
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